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EXPLOSIVES DEPARTMENT

R.A.R.D.E. MEMORANDUM 38/72

The effect of added water on explosive performance as measured by the Lidstone Cartridge Case Test

H C Sayce

Fort Halstead
KENT

December
1972

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ROYAL ARMAMENT RESEARCH AND DEVELOPMENT ESTABLISHMENT

RARDE MEMORANDUM 38/72

The effect of added water on explosive performance as measured by the Lidstone Cartridge Case Test

H C Sayce (EM2)

Summary

The desensitising effect of water on the explosive performance of 15 substances has been assessed by cartridge case deformation tests. The results appear to be valid for explosive in quantities appreciably larger than the test samples. Variations in particle size of an explosive are not likely to be significant.

Approved for issue:

D F Runnicles, Head, 'EM' Department

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1. INTRODUCTION

The results from the Lidstone Cartridge Case Test[1] have been shown to give a measure of the explosive performance of explosives. In the test 2 g of an explosive at its normal packing density is contained in a .303 inch (7.7 mm) cartridge case and subjected to the shock from a No.6 electric detonator. The weight of the remaining base of the cartridge case is a measure of the performance of the explosive. For example the base weight for a high explosive such as RDX is 2 g and for a deflagrating explosive such as Gunpowder is 6.9 g.

The performance of an explosive in this test can be modified in several ways. For example, a material with marginal explosive properties such as m dinitrobenzene can exhibit detonative* or non explosive performance according to the density of packing in the cartridge case. Its performance can also be modified by changing the strength of the initiator. These properties have been used to develop the cartridge case test as a means of measuring the performance of detonators[2].

In the present work, a study has been made of the effect of water on explosive performance, as measured by the Lidstone Cartridge Case Test, of 15 substances namely PETN, RDX, tetryl, 1,3,5 trinitrobenzene, RDX/TNT 80/20, strontium picrate, styphnic acid, 2,4,6 trinitrobenzoic acid, picric acid, TNT, ammonium picrate, mealed gunpowder, nitroguanidine, 2,4 dinitrophenol and sodium 2,4 dinitrophenate. In most cases, the performance changes abruptly from that of detonation to deflagration and/or a non explosive condition as the quantity of water in the mixture is increased. The quantities of water at which the discontinuities occur are in reasonable agreement with the amount of water required under the Explosives Act 1875 to render certain explosives non-hazardous[3]. For example, Order in Council No.26, for the purposes of conveyance states that "picric acid mixed with not less than half its own weight of water shall not be deemed to be an explosive within the meaning of the Act". RDX and PETN are authorised for transport as explosives only when wetted with not less than 25% water calculated on the wet explosive[4].

The present work also includes consideration of the effects of particle size and scaling up factors.

2. EXPERIMENTAL

2.1 Witness devices used for the tests

The Lidstone Cartridge Case Test, which yielded most of the results reported, has been described in detail previously[1]. The .303 inch (7.7 mm) cartridge case used in this work was a particularly useful witness vessel, no filling difficulties being experienced as a result of the greater bulk of charge arising from the wetting of some of the explosives with relatively large quantities of water.

*It is most probable that the performance regimes close to the transitional zone correspond to deflagration and detonation but final confirmation awaits the outcome of further experiments.

For tests involving scaling-up to larger charge weights the 30 mm Aden cartridge case was selected. This case has an internal volume of 69 ml and can accept 50 g charges of most explosives without difficulty.

2.2 Preparation of the explosive/water mixture

Two grams of explosive are weighed into a 10 ml glass crystallising dish and the appropriate quantity of water is added slowly from a burette. The ingredients are mixed together thoroughly using a small glass rod for at least 3-4 minutes in order to achieve a completely homogeneous mixture. This is immediately filled into the cartridge case to obviate possible losses in water content due to evaporation and the charge is prepared for firing without delay. A 2 g quantity of explosive is taken for all wetted samples, rather than 2 g of the wet explosive.

When mixtures with gelled water are required (see 4.4 below), a moderately thin gel of water with Polycell is first prepared in a 400 ml beaker. The appropriate quantity of gel for the test is weighed into a 30 ml squat beaker, 2 g of explosive is added to it and the whole is mixed together thoroughly with a glass rod until the mixture is homogeneous. It is then filled into the cartridge case as described above.

For tests involving larger quantities, 50 g of explosive are weighed into a 100 ml glass beaker and the appropriate quantity of water is again added from a burette. The ingredients are mixed very thoroughly with a glass rod, perhaps as long as 5 minutes mixing may be necessary, until homogeneity is achieved. The mixture is then immediately loaded into a 30 mm cartridge case and the charge made ready for firing.

2.3 Test procedures

2.3.1 The cartridge case test

The equipment for the cartridge case test on wet samples is illustrated in Fig 1. Apart from the wetting of the explosive described at 2.2, procedure is precisely the same as described by Lidstone[1].

2.3.2 The larger scale test

The assembly for tests with the 30 mm cartridge case is illustrated in Fig 2. At the time of firing this is surrounded by a heavy, empty shell case, open at the top.

With most explosives tested at the larger scale, 50 g charges prepared in two conditions were fired in duplicate. These conditions were:- (a) dry, (b) wetted with a proportion of water which had produced a non-explosive result in the small test, ie with a 2 g charge. In the case of picric acid, charges wetted to several additional levels were also fired.

The prepared charge containing 50 g of explosive is filled into a 30 mm brass cartridge case and packed down at several stages of the filling with a simple hand stemming tool. A depth-gauge is lowered into the cartridge case to the level of the top of the explosive charge. From the gauge reading the density of the charge is calculated.

To hold the detonator in position against the surface of the charge a circular sleeve of ½ inch thick polyurethane foam is cut to a size to permit a tight sliding fit in the cartridge case. A hole is bored in the centre of this sleeve into which a Nobel's No.6 electric ASA-PETN type detonator, aluminium, flat-based, may be firmly inserted such that the detonator base is level with the remote side of the sleeve. This assembly is inserted into the cartridge case and lowered to engage the top surface of the charge. The prepared cartridge is placed base downwards on a sheet of thin cardboard covering a cylindrical steel tube containing several wads of cotton-wool and standing on a piece of softwood approximately 1½ inches thick. An empty shell case, open at the top, is placed over the firing assembly to absorb some of the blast from the explosion.

Firings of these larger charges must be done in a specially designed explosion chamber permitting a remotely-operated firing mechanism.

After the charge has been fired the major portion comprising the cartridge base is recovered. The recovered portion is cleaned, including removal of unfired explosive where necessary, washed in water, dried and weighed. The result of the test is evaluated from the extent of the deformation and the weight of the recovered portion of the case.

3. RESULTS

3.1 The cartridge case test

Table 1 shows the detailed results obtained with 15 selected explosives. Two of these explosives, styphnic acid and nitroguanidine, have been examined at different grists. Normally duplicate firings are made at each level of wetting.

Fig 3 shows a typical set of deformed cases after test. These are for picric acid, which for additions of 0, 10, 15, 20, 30 and 40% of water gives mean base weights of 2.34, 2.43, 3.07, 7.05, 7.74 and 8.18 g respectively, showing that failure to detonate occurs in the region between 15 and 20% added water.

The desensitising effect of water on each of the explosives under examination is shown graphically in Figs 4 to 23. It is clear that with three high explosives - PETN, RDX and RDX/TNT 80/20 - even an excess of water above what could adequately be absorbed by the explosive fails to prevent detonation in the normal test. Table 4 lists the approximate safe limits of added water determined from these graphs. Adequate tolerances would be necessary for recommended levels of wetting in practice.

3.2 The larger scale test

Table 2 gives the results from firings of 50 g quantities of explosives. These were done with 4 explosives only to confirm the findings of the cartridge case test using 2 g quantities. The number of firings were also

limited, normally to that of the dry explosive and of the minimum level of added water at which a 'non-explosive' result had been obtained in the smaller scale test. With picric acid some additional levels of added water were examined.

Fig 24 shows the effect on the 30 mm cartridge case of firings of TNT when (a) dry, producing detonation, and (b) wetted with 20% added water, producing a 'non-explosive' result. These are typical specimens.

3.3 Tests with gelled water systems

The results of these tests with three of the explosives under examination, which involved large additions of water in the form of a gel, are recorded in Table 3. The effects are shown graphically in Figs 19, 21 and 23.

4. DISCUSSION

4.1 The sigmoid curve

An interesting feature of the cartridge case test results with most of the explosives examined is the nature of the curve obtained by plotting base weight against percentage of added water. It is invariably a sharply-defined sigmoid shape, giving a clear-cut record of the sudden change from the level of wetting at which the explosive exhibits high performance to the level at which the mixture is non-explosive. There are several instances among the results of a pair of widely differing test results occurring at a particular level of wetting. This indicates that the abrupt change from 'detonation' to a point approaching the 'non-explosive' condition, which is taken to be a base weight of 7.5 g or greater, takes place at precisely that level of wetting. The choice of 7.5 g as the non-explosive limit was made by Lidstone [1] because at this base weight and greater only the upper part of the cartridge case wall, ie that part adjacent to the detonator, became petalled; the lower wall and base remained unaffected and thus indicated that no propagation had occurred through the charge.

Only two of the explosives examined in this study have failed to produce a sigmoid curve. These are sodium 2,4 dinitrophenate, which is non-explosive when dry under the conditions of the test, and mealed gunpowder, which gives a performance of moderate deflagration when dry and is therefore too close to the non-explosive condition to produce a sharply defined curve when subsequently wetted. The result with the former is not surprising, in view of that found with the parent compound 2,4 dinitrophenol. The performance of this latter explosive is readily affected by the presence of water, inasmuch as the abrupt change in the curve takes place at around the level of 2% added water and it becomes non-explosive with about 4% added water. The coupling of the sodium ion to the molecule would be expected, from a knowledge of its effect with other nitrophenols, to reduce explosive performance. In fact, the coupling produces a salt which is non-explosive, in this test. This substance may not be regarded as safe in the dry state since it would be readily ignited by spark or friction and act as a deflagrating explosive (see section 1).

4.2 Effect of particle size

Two explosives have been examined in this context, styphnic acid and nitroguanidine. Both are able to detonate in the test when dry, though nitroguanidine does so only with moderately low performance. Good agreement is shown in the performance of different grists of each explosive when tested in the dry state. In view of only minimal differences in charge density, this would be expected.

The grists used for this examination are not ideally at opposite ends of the particle size scale. Minimum quantities required for testing dictated which sieve fractions of the explosive samples could be used. Nevertheless, if particle size is a genuinely critical factor in explosive performance in the wet state, it is thought that the results obtained in this study would indicate that fact.

In the event only small differences have been found between the levels of wetting required to effect the change in performance from detonation to one approaching a non-explosive condition. With the larger size of styphnic acid this change occurs at around 16-17% added water and with the finer grist at 20% added water. In the case of nitroguanidine no significant difference can be measured in the level of wetting required for the different grists. Reference to the results in Table 1 and to Figs 16 and 17 shows that the change in performance of each grist clearly occurs at the level of $2\frac{1}{2}$% added water. It is unfortunate that this value is so small, since it would inevitably mask any slight difference that may be present.

From the rather limited evidence of this examination it would appear to be unlikely that particle size has any great bearing on the performance of explosives in the wet condition.

4.3 Scaling-up

As is well known, the behaviour displayed by explosives in small-scale tests is not always followed by larger quantities of these materials when subjected to similar tests. This is particularly true of factors such as explosive performance. It became necessary, therefore, to carry out experiments with appreciably larger amounts of explosive to ensure that the results of the small-scale tests remained valid.

Consideration was given to the form of initiation to be employed in these experiments in which the quantity of explosive had been increased by 25 times. The use of a more powerful detonator, perhaps boosted by a layer or two of sheet explosive such as Metabel, would seem to be the obvious step. However, it is necessary to reflect whether in fact the wet explosive would, in practice, ever be subjected to a shock impulse as great as that delivered by this kind of initiating system. Even high velocity metal fragments derived from an explosion in close proximity would scarcely produce a shock approaching this order of magnitude. To avoid unrealistically excessive initiation, therefore, the use of the No.6 detonator has been continued for all the larger scale tests. It is felt that the shock impulse delivered by this detonator is quite adequate to meet all practical requirements.

This study has been extended to only 4 of the explosives, which are considered to be sufficient to confirm the evidence presented by the cartridge case test itself. Taking from the graphs the lowest quantity of water necessary to produce a non-explosive performance, tests have been done at the 50 g scale with each explosive. On comparing the weight and appearance of the cartridge cases after test with those from similar tests with the dry explosive, it is clear that in each instance the degree of wetting has produced the same result.

No petalling of the wall of the cartridge case is produced by non-explosive performance under these test conditions at the 50 g scale. There is a variable extent of bulging on those areas of the wall adjacent to the siting of the detonator, usually accompanied by slits in the wall in the region of the bulge (see Fig 24). The different effect with this cartridge case, compared with that of the smaller case used at the 2 g scale, is that the shock wave largely dies out between the detonator and the wall of the case. Also, there is no propagation along the length of the case, which is confirmed by considerable amounts of unfired explosive present in the case after test.

The same effect is shown by picric acid when wetted to several different levels. A 26% addition of water is required to produce non-explosive performance with this explosive at the 2 g scale. However, when tested with additions of 20% and 10% water at the 50 g scale, non-explosive performance is still obtained.

There is therefore a distinctly less marked tendency for the detonation to propagate through a greater bulk of wetted explosive. The cases from firings with 10% added water are more bulged and have larger slits in the wall than those from firings with 20% and 30% added water, which are very similar in appearance. This indicates that the detonation wave has died somewhat less rapidly in this instance between detonator and wall of the case, but it is also clear from the weights recorded after trial that no propagation has occurred through the main bulk of explosive along the length of the case.

It can be argued that more efficient initiation would yield quite different results in the firings of these 50 g charges. This may be true but, as stated earlier, it is not the criterion on which practical considerations are based for this particular application. For the purpose of storage and transport of wet explosive it is most unlikely that a situation would ever arise in which a mass of explosive could fortuitously be subjected to efficient initiation. The form of initiation to be expected in such circumstances would probably be weak - less efficient, that is, than the initiation of 50 g charges in these tests by a No.6 detonator. Thus the results of these scaling-up trials are reassuring in that the minimum water additions required to suppress detonation at the 2 g level likewise cause suppression of detonation at the 50 g level. Indeed there is some evidence to suggest that a 50 g charge may be rendered non-explosive by a lower level of water addition than that required for a 2 g charge.

It should be noted that, in this test, only small diameter charges are used, ie the parameter, critical diameter has not been considered.

4.4 Gelled water systems

The essential value of gelled water as a means of wetting explosives is that it enables tests to be carried out at levels of water addition far beyond the limit of adsorption that an explosive reaches in admixture with distilled water. In the present study only 3 explosives - PETN, RDX and RDX/TNT 80/20 - have required the use of gelled water for testing. The results for these explosives in Table 1 show that at the limit of adsorption with distilled water, and perhaps a little beyond it, explosive performance remains firmly in the detonation category. No further tests could be contemplated at higher levels of wetting owing to the difficulty of handling the excess distilled water.

However, a mixture of explosive with the appropriate weight of gelled water produces a uniform paste which can be filled into the cartridge case with reasonable convenience and onto which the detonator may be inserted in position in the usual way. It is not greatly different in handling characteristics from fairly wet mixtures of explosive with distilled water. Table 3 demonstrates the quite large amounts of added water with which it is possible to test explosives using gelled water systems. The same sharp transition from 'detonation' to 'non-explosive' performance is evident from the results and is well illustrated by the clearly defined sigmoid curves of the graphs (see Figs 19, 21 and 23).

It is noteworthy that among firings involving gelled water systems in which detonation performance is obtained, the base of the cartridge case is badly fragmented almost without exception. Sometimes the base is broken into a dozen or so small fragments which are very difficult to locate among the expanded mica; this difficulty has probably resulted in spuriously low values for base weight reported in certain instances. The effect appears to be due to the interstices between crystals of the explosive being more completely filled by the gel than by distilled water and the gel thus acting as a more efficient medium for propagation of the shock wave.

The gelling of bulk explosive offers itself as a possible practical application in the safe storage and transport of these materials. When the explosive is required for use the gel could be washed away in a stream of water and the explosive then dried. Only explosives having negligible solubility in water would be suitable for this treatment, so any application would necessarily be a limited one.

4.5 Relationship with other explosive factors

The first substances to be examined in this study were a number of specified, low performance explosives. Subsequently the work was extended to include some explosives of known higher performance and it was notable from the results that these explosives all required high levels of wetting to be rendered non-explosive. Consideration was therefore given to possible correlations between this wetting level and certain other properties of the explosives. It was thought that conditions might be found whereby it was possible to predict safe limits of water-wetting for a given explosive with reasonable accuracy.

An examination has consequently been made to see if any relationship exists between the quantity of water required to induce the initial sharp change from detonation to a non-explosive condition and other explosive properties such as power, sensitivity, etc. Plotting this limiting quantity of water, expressed as a percentage of the explosive/water mixture, against Power, calculated by the simple method described by Martin and Yallop[5], produces a set of points through which a straight line might very approximately be drawn. There is however an appreciable scatter among these points and, more importantly, there are several points that are widely divergent from the general trend. Thus a valid relationship does not appear to exist.

Similarly if a graph is plotted of the smallest percentage of water necessary to produce a completely non-explosive condition against Power (calculated), a gentle curve is produced which passes through most of the points satisfactorily. The scatter is less than in the above-mentioned graph, but there is still one point, that for RDX,which is widely divergent from this curve and which cannot be explained. At best, only an approximate relationship can be claimed (see Fig 25).

Similar graphs in which these percentages of water are plotted against the Figure of Insensitiveness of the explosive, as determined by the Rotter Impact Test (relative to RDX = 80), reveal no satisfactory relationship. The scatter of points is considerable and there are again several points widely divergent from the general trend.

5. CONCLUSIONS

The test assesses the effects of a standard initiatory system on water-wetted explosives. Minimum additions of water for non-explosive performance are reported in Table 4. Increased amounts of water above these values may be required if there is a risk of more vigorous initiation.

There are indications that the test results are valid for explosive in large quantity. When charge weights are increased by a factor of 25 the desensitisation of explosives by water is at least as good for initiation by a No.6 detonator.

Particle size of an explosive does not appear to be a critical factor in the level of wetting required for non-explosive performance. Only small differences in safe limits exist with the two explosives examined and it is possible that a blanket ruling could be given where necessary to cover all sizes of grist of an explosive.

The use of water in the form of a gel permits large additions to be made where necessary for the complete testing of certain explosives.

6. ACKNOWLEDGEMENTS

The author wishes to thank Mr H J Yallop, who directed the work, and Mr A R Martin for helpful discussions and advice on the presentation of this Memorandum, and Mr D P Lidstone for invaluable experience and advice at all stages of the experimental programme.

7. REFERENCES

1. D P Lidstone, Explosivstoffe, 9, 1969, 193-201.

2. D P Lidstone, unpublished work.

3. Explosives Act 1875, Order in Council No.26, June 28, 1926
   " " " , Order in Council No.27, June 27, 1927
   " " " , Order of Secretary of State No.7, June 10, 1904.

4. Explosives Acts 1875 and 1923, List of Authorised Explosives, pages 13 and 16, 1972.

5. A R Martin and H J Yallop, J. Appl. Chem., 1959, 9, 310-315.

TABLE 1

Effects of the water-wetting of explosives measured by the cartridge case test using 2 grams of explosive (No. 6 detonator)

Explosive	Water added (calculated on wt of explosive) %	Density of charge g/cm^3	Base weight g	Mean weight g
Picric acid	nil	1.0 1.0	2.31 2.36	2.34
	10	1.1 1.1	2.41 2.45	2.43
	15	1.1 1.1	3.05 3.08	3.07
	20	1.2 1.1	7.47 6.63	7.05
	30	1.3 1.3	7.40 8.08	7.74
	40	1.4 1.4	8.43 7.93	8.18
TNT crystalline	nil	0.9 0.9	2.84 2.87	2.86
	10	1.0 1.0	2.84 2.76	2.80
	15	1.1 1.1	6.00 3.37	-
	20	1.1 1.1	7.67 7.37	7.52
	30	1.2 1.3	7.86 8.07	7.97
2,4 Dinitrophenol	nil	1.0 1.0	3.31 3.56	3.44

TABLE 1 (cont'd)

Explosive	Water added (calculated on wt of explosive) %	Density of charge g/cm^3	Base weight g	Mean weight g
2,4 Dinitrophenol (cont'd)	2	1.0 1.0	6.37 5.75	6.06
	5	1.0 1.0	8.09 7.67	7.88
	10	1.1 1.1	7.88 8.44	8.16
	20	1.2 1.2	8.36 8.46	8.41
Sodium 2,4 dinitrophenate	nil	1.0 1.0	7.71 7.76	7.73
	5	1.2 1.2	7.54 7.28	7.41
1,3,5 Trinitrobenzene	nil	0.8 0.8	2.99 2.88	2.94
	10	0.9 0.9	2.98 2.88	2.93
	20	1.0 1.0	2.81 2.87	2.84
	30	1.1 1.1	2.31 2.80	2.56
	40	1.1 1.2	2.70 2.45	2.58
	50	1.2 1.2	2.83 2.46	2.65
	55	1.3 1.3	7.09 8.21	7.65
	60	1.3 1.2	7.54 8.14	7.84

TABLE 1 (cont'd)

Explosive	Water added (calculated on wt of explosive) %	Density of charge g/cm^3	Base weight g	Mean weight g
2,4,6 Trinitrobenzoic acid	nil	0.8 0.8	3.02 3.02	3.02
	10	1.0 1.1	2.95 2.94	2.95
	20	1.0 1.0	3.01 2.93	2.97
	25	1.0 1.0	6.03 3.09	-
	30	1.3 1.2	7.59 8.37	7.98
	40	1.5 1.5	7.21 7.56	7.39
PETN	nil	1.0 1.0	2.60 2.68	2.64
	10	1.0 1.0	2.49 2.71	2.60
	20	1.1 1.1	2.37 2.74	2.56
	30	1.2 1.3	2.51 2.43	2.47
	40	1.3 1.3	2.21 2.28	2.25
	50	1.4 1.4	2.18 2.30	2.24
	60	1.4 1.5	2.31 2.30	2.31
	70	1.6 1.7	2.32 2.33	2.33

TABLE 1 (cont'd)

Explosive	Water added (calculated on wt of explosive) %	Density of charge g/cm^3	Base weight g	Mean weight g
RDX	nil	1.1 1.0	1.99 1.99	1.99
	50	1.7 1.7	2.01 2.30	2.15
RDX/TNT 80/20	nil	1.2 1.2	1.92 2.10	2.01
	30	1.6 1.5	2.14 1.98	2.06
	40	1.5 1.6	1.88 1.98	1.93
Tetryl Grade I, crystalline	nil	1.1 1.1	2.34 2.31	2.33
	40	1.5 1.6	2.23 2.30	2.27
	45	1.6 1.6	6.15 2.29	-
	50	1.6 1.6	7.14 6.50	6.82
	60	1.6 1.6 1.6	7.79 7.21 7.50	7.50

TABLE 1 (cont'd)

Explosive	Water added (calculated on wt of explosive) %	Density of charge g/cm^3	Base weight g	Mean weight g
Ammonium picrate	nil	1.2 1.2	3.51 3.46	3.49
	4	1.1 1.2	6.08 5.11	5.60
	5	1.2 1.2	5.28 6.24	5.76
	6	1.2 1.2	7.45 6.98	7.22
	10	1.3 1.3	7.44 7.71	7.58
	20	1.5 1.5	7.56 7.45	7.51
Strontium picrate	nil	1.0 1.0	3.08 2.98	3.03
	10	1.0 1.1	3.14 3.02	3.08
	20	1.1 1.1	3.09 2.95	3.02
	25	1.1 1.1	3.00 3.08	3.04
	30	1.1 1.1	7.68 7.20	7.44
	40	1.2 1.3	8.32 8.00	8.16
Gunpowder (mealed)	nil	0.9 1.0	6.74 7.06	6.90
	2	1.2 1.2	7.26 7.38	7.32
	4	1.2 1.2	6.89 7.42	7.16
	5	1.2 1.2	6.81 7.22	7.02
	7	1.3 1.3	7.72 7.24	7.48

TABLE 1 (cont'd)

Explosive	Water added (calculated on wt of explosive) %	Density of charge g/cm^3	Base weight g	Mean weight g
Styphnic acid (pass 30 BSS-rtd 100 BSS)	nil	1.0 1.0	2.96 2.32	2.64
	15	1.2 1.2	2.81 2.41	2.61
	17½	1.3 1.3	6.53 6.56	6.55
	20	1.2 1.3	7.36 6.65	7.01
	30	1.5 1.5	7.35 7.09	7.22
Styphnic acid (all pass 100 BSS)	nil	1.0 1.1	2.69 2.62	2.66
	15	1.2 1.2	2.81 2.18	2.50
	20	1.3 1.4 1.3	2.89 5.60 5.53	-
	25	1.4 1.4	7.22 6.76	6.99
	30	1.4 1.5	7.73 7.22	7.48
Nitroguanidine (pass 40 BSS-rtd 80 BSS)	nil	0.9 1.0	3.41 3.45	3.43
	2½	1.0 1.0	6.78 3.81	-
	5	1.0 1.0	6.87 7.04	6.96
	10	1.0 1.0	7.89 7.95	7.92
	20	1.1 1.2	8.39 8.37	8.38

TABLE 1 (cont'd)

Explosive	Water added (calculated on wt of explosive) %	Density of charge g/cm^3	Base weight g	We . t g
Nitroguanidine (all pass 80 BSS)	nil	1.1 1.1	3.41 3.34	3.38
	$2\frac{1}{2}$	1.0 1.0	5.15 3.44	-
	5	1.1 1.0	7.28 6.96	7.12
	10	1.1 1.1	8.19 8.25	8.22
	20	1.2 1.2	8.32 8.37	8.35

TABLE 2

Effects of the water-wetting of explosives measured by the larger scale test using 50 grams of explosive (No.6 detonator)

Explosive	Water added (calculated on wt of explosive) %	Density of charge g/cm^3	Weight of base or deformed case g
Picric acid	nil	1.0	18.3
		1.0	22.2
	10	1.2	167.7
		1.2	169.4
	20	1.3	168.9
		1.4	168.5
	30	1.3	169.5
		1.3	170.5
Styphnic acid (all pass 100 BSS)	nil	1.2	25.2
		1.2	25.6
	30	1.4	168.2
		1.4	170.5
TNT crystalline	nil	0.9	30.4
		0.9	32.9
	20	1.2	168.5
		1.2	167.5
Tetryl Grade I, crystalline	nil	1.1	49.4
		1.1	33.4
	50	1.5	169.8
		1.5	168.9

TABLE 3

Effect of Wetting Explosives with Gelled Water measured by the Cartridge Case Test using 2 grams of Explosive (No.6 detonator)

Explosive	Gelled Water added (calculated on wt. of explosive) %	Base weights g	Mean weight g
PETN	nil	2.60 2.68	2.64
	100	1.8 approx	-
	150	2.60 2.56	2.58
	160	6.91 4.41	-
	170	8.17 9.13	8.65
	180	9.04 8.10	8.57
RDX	nil	1.99 1.99	1.99
	50	1.75 1.71	1.73
	55	2.13 duplicate not completely recovered	-
	60	9.85 8.74	9.30
	70	8.34 8.25	8.30
RDX/TNT 80/20	nil	1.92 2.10	2.01
	40	8.05 2.40	-
	45	7.97 2.53	-
	50	8.70 8.90	8.80

TABLE 4

Limits of water-wetting of explosives when subjected to contact impulse of a detonator

Explosive	Minimum water addition (calculated on wt of dry explosive) for non-explosive performance as derived from mean values on graphs
	%
PETN	165
RDX	60
Tetryl grade I cryst	60
1,3,5 Trinitrobenzene	55
RDX/TNT 80/20	48
Strontium picrate	31
Styphnic acid	30
2,4,6 Trinitrobenzoic acid	28
Picric acid	26
TNT cryst	20
Ammonium picrate	8
Gunpowder, meaied	7
Nitroguanidine	6
2,4 Dinitrophenol	4
Sodium 2,4 dinitrophenate	nil

FIG.1

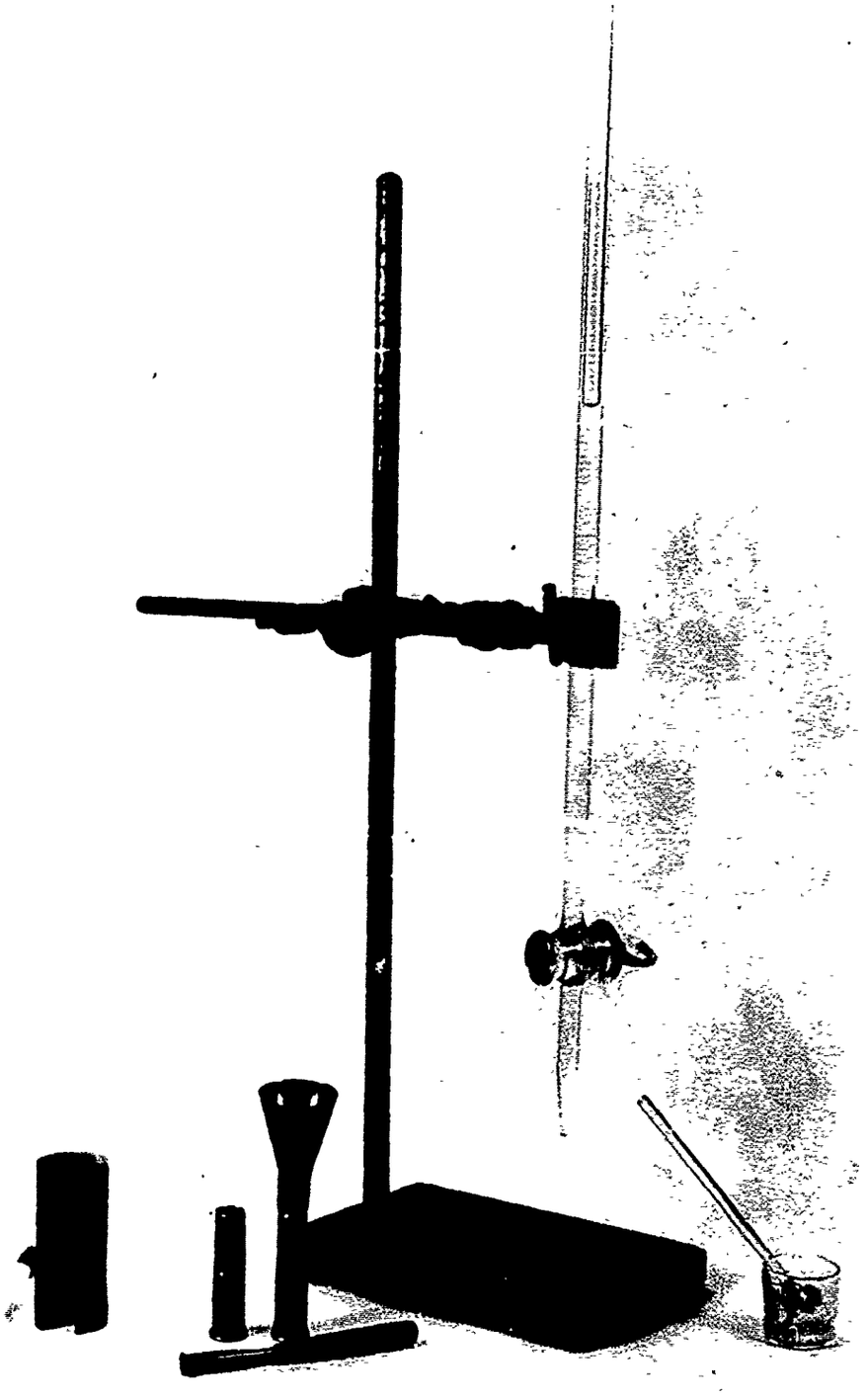


FIG.1 EQUIPMENT FOR PREPARING WET CHARGES IN THE CARTRIDGE CASE TEST SHOWING (r TO ℓ) THE GLASS MIXING DISH AND ROD, BURETTE FOR MEASURING WATER ADDITIONS, BRASS FUNNEL IN NECK OF CARTRIDGE CASE FOR FILLING THE CHARGE, HAND-STEMMING TOOL, DENSITY MEASURING GAUGE

FIG.2

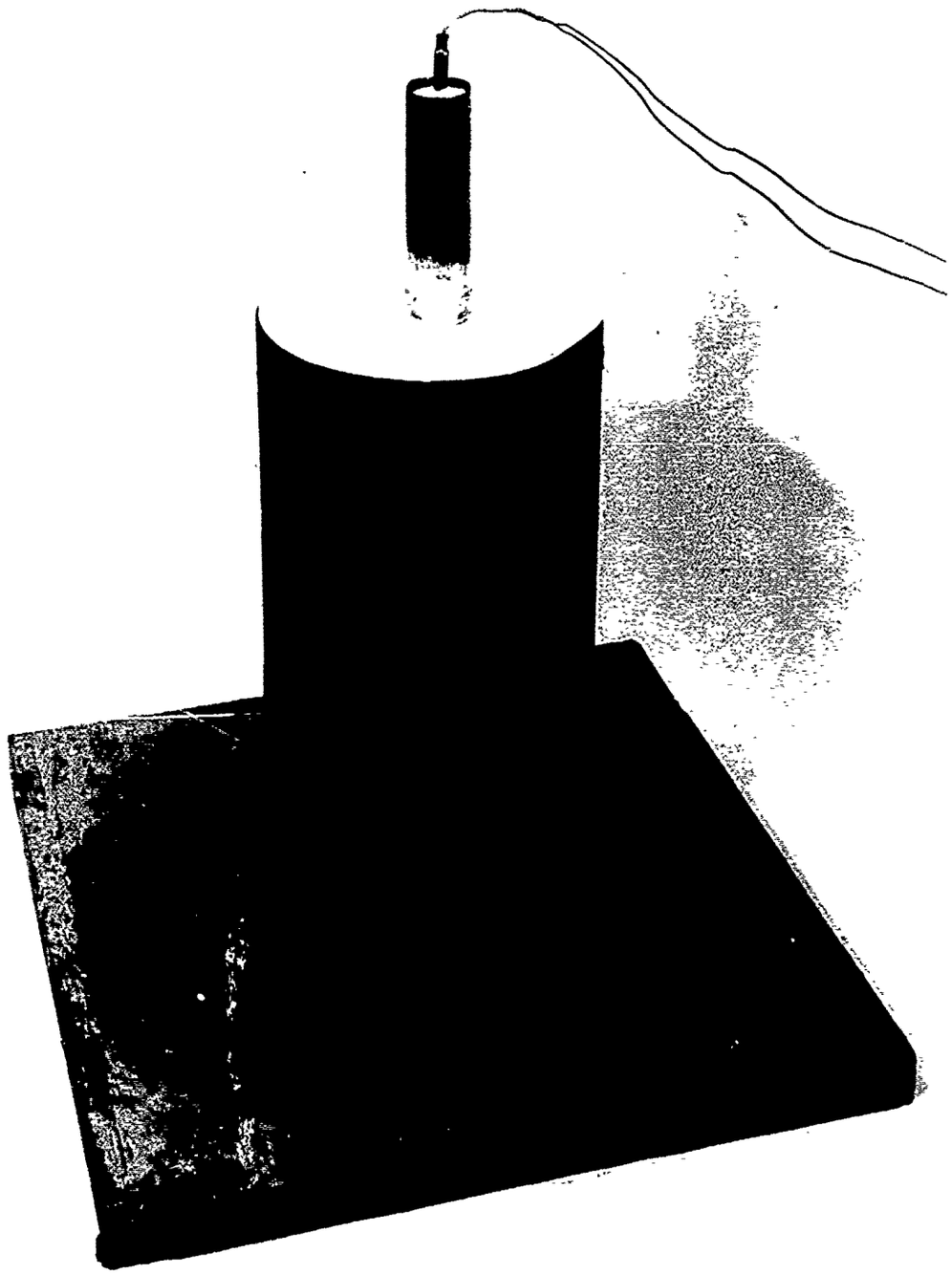


FIG.2 FIRING ARRANGEMENT FOR THE LARGER SCALE TEST SHOWING ASSEMBLED 30 mm CARTRIDGE CASE SUPPORTED BY CARDBOARD DISC PLACED OVER CYLINDRICAL STEEL TUBE

FIG.3

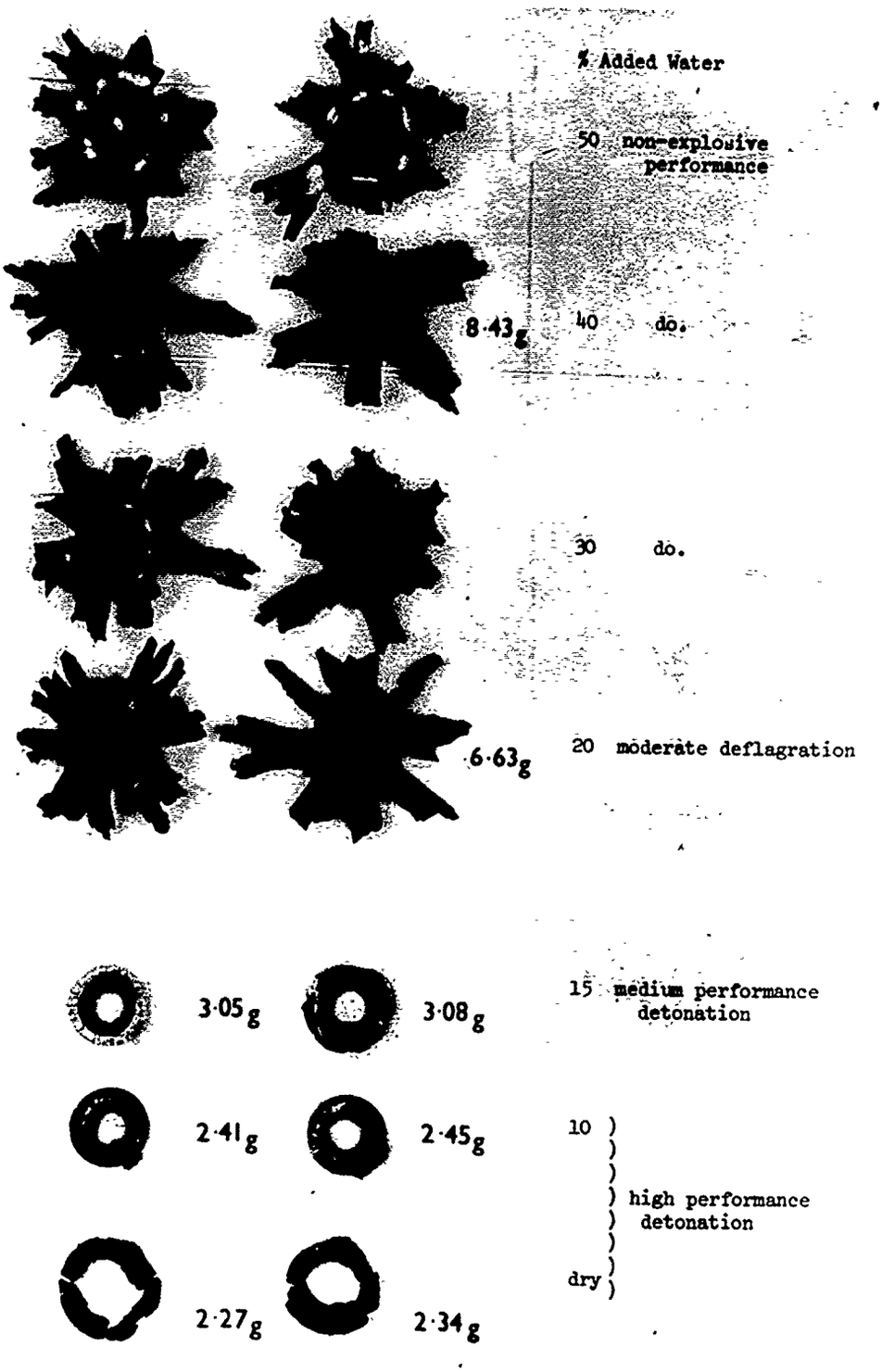


FIG.3 TYPICAL DEFORMED CASES FROM FIRINGS OF DRY AND WETTED PICRIC ACID

FIGS.4 & 5

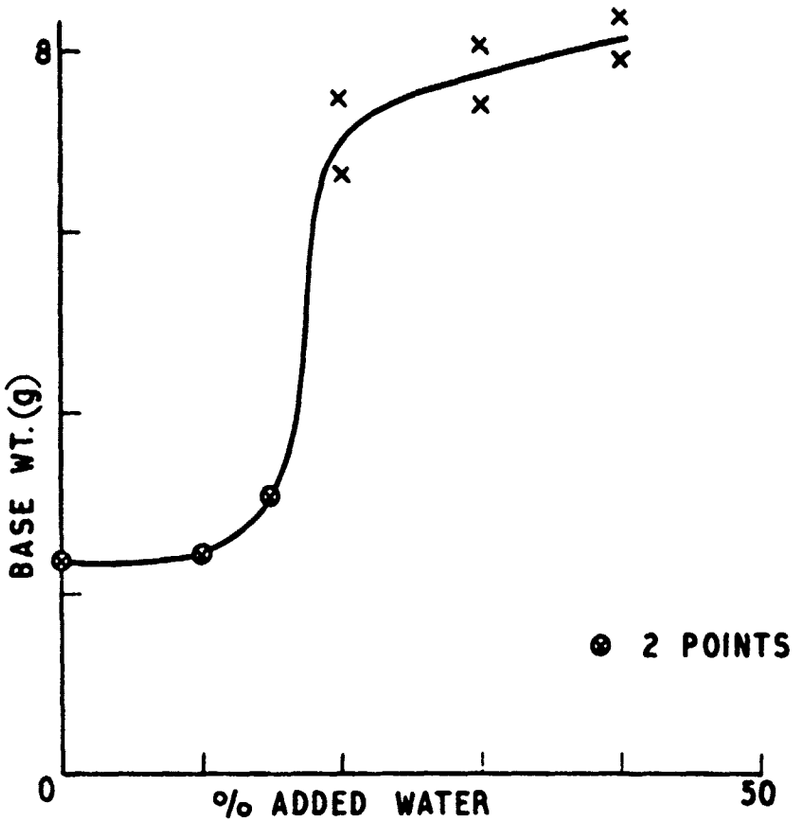


FIG. 4 C.C. TESTS OF PICRIC ACID/WATER

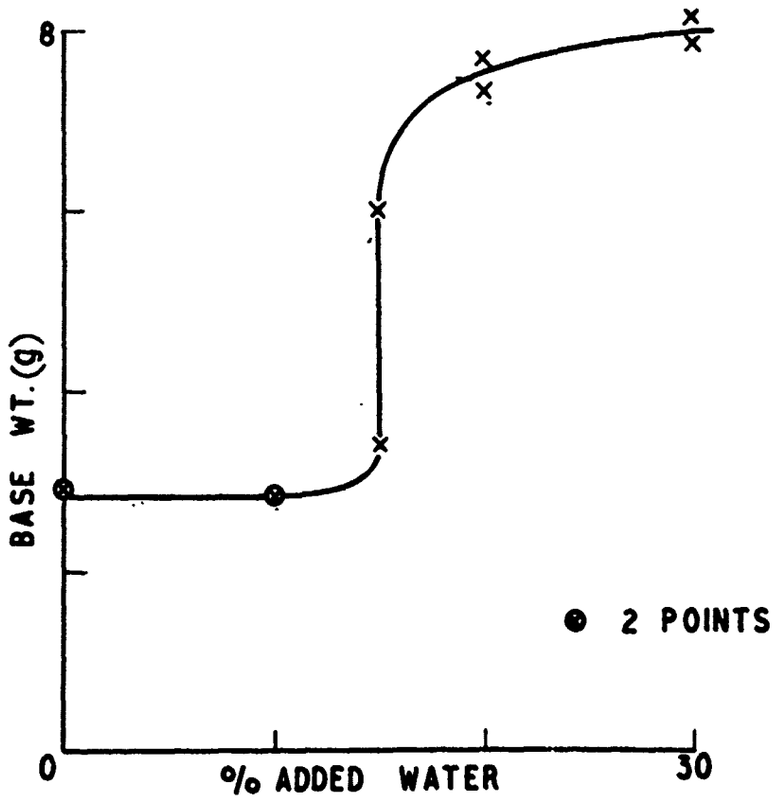


FIG. 5 C.C. TESTS OF TNT/WATER

FIGS.6 & 7

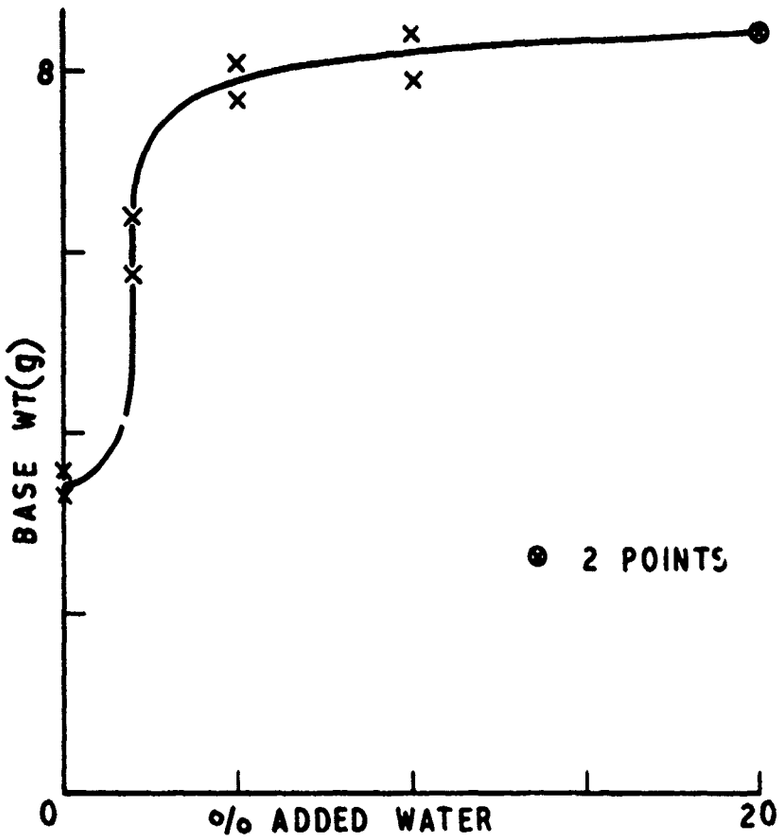


FIG:6 C.C. TESTS OF 2:4 DINITROPHENOL / WATER

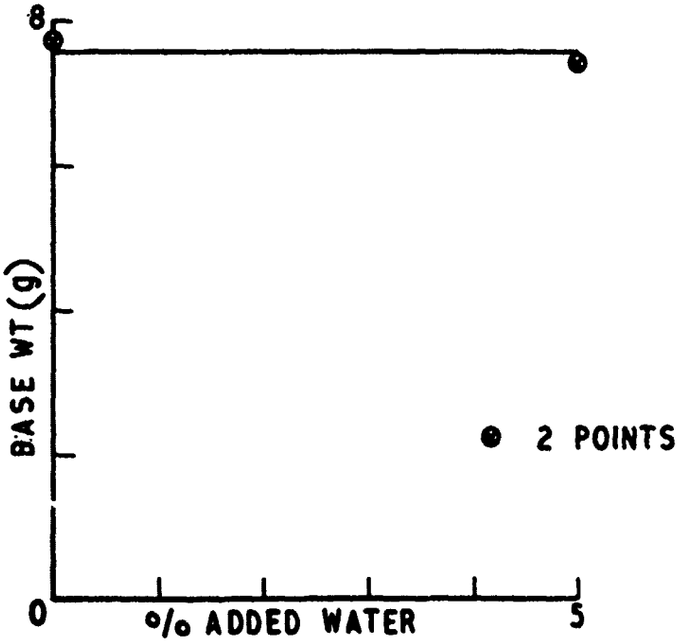


FIG.7 C.C. TESTS OF SODIUM 2:4 DINITROPHENATE/WATER

FIGS.8 & 9

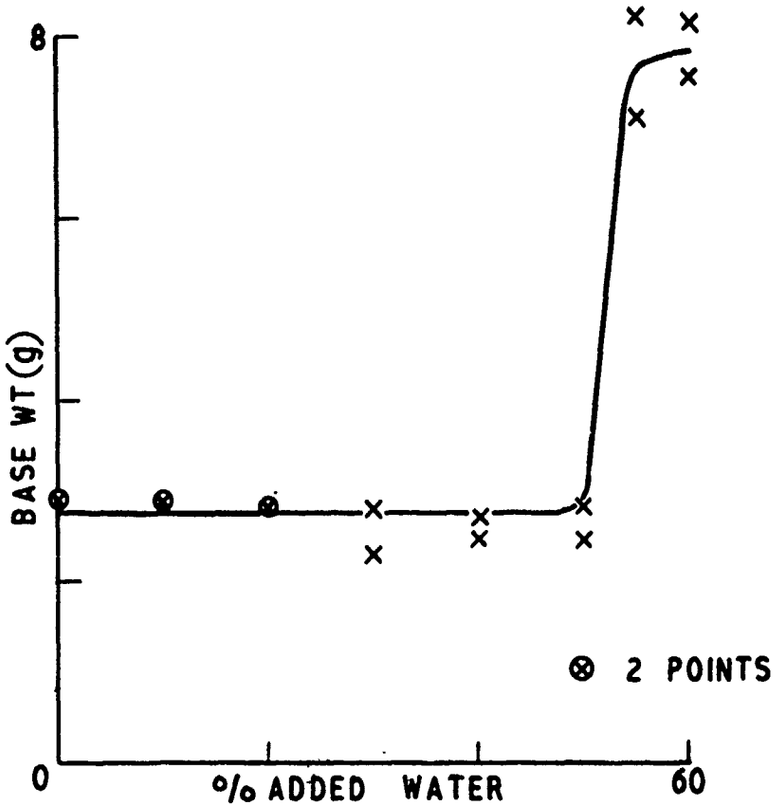


FIG.8 C.C. TESTS OF 1:3:5 TRINITROBENZENE / WATER

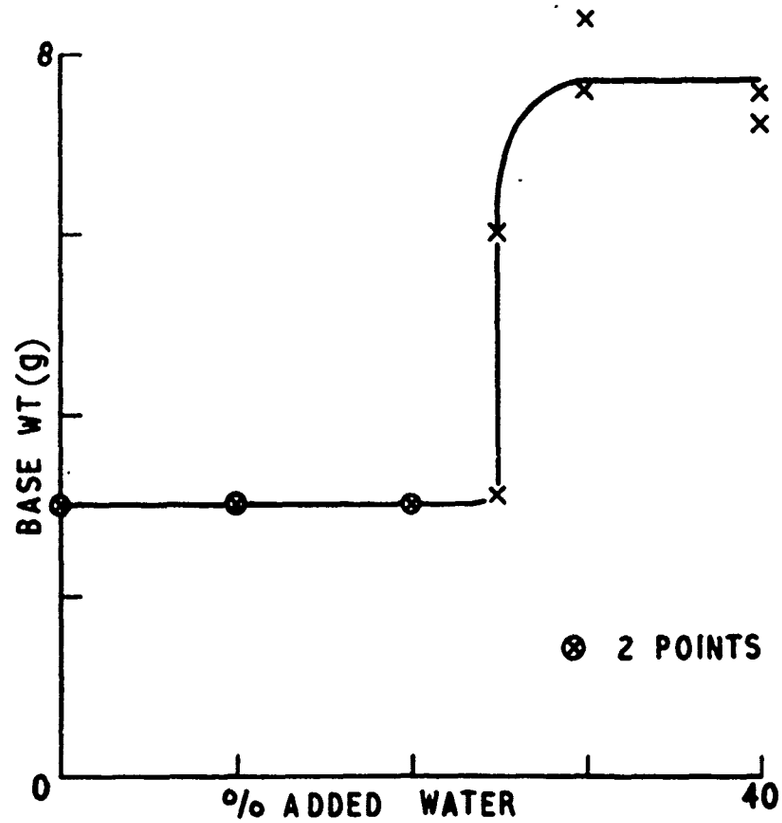


FIG.9 C.C. TESTS OF 2:4:6 TRINITROBENZOIC ACID/WATER

FIGS. 10 & 11

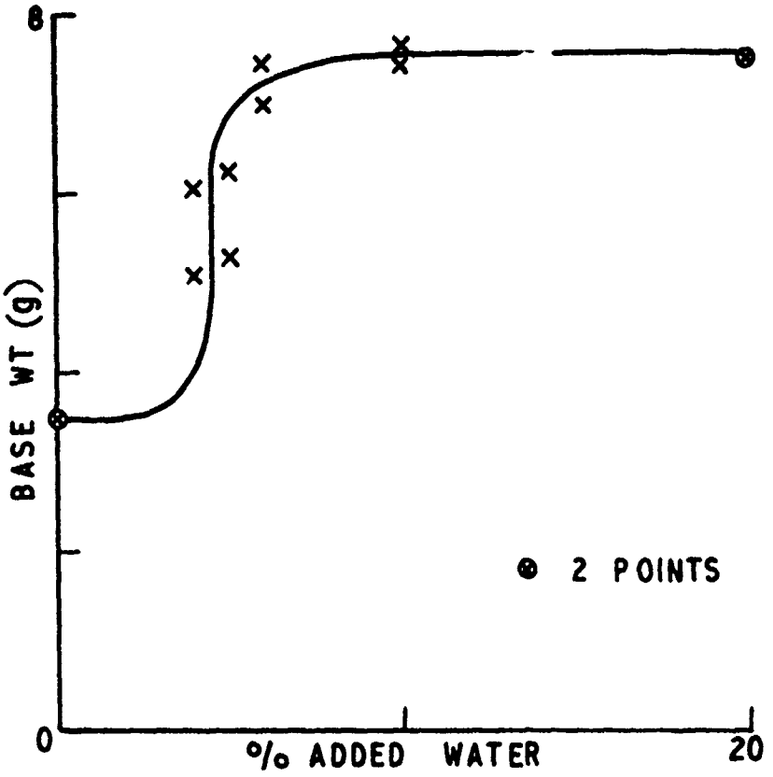


FIG. 10 C.C. TESTS OF AMMONIUM PICRATE / WATER

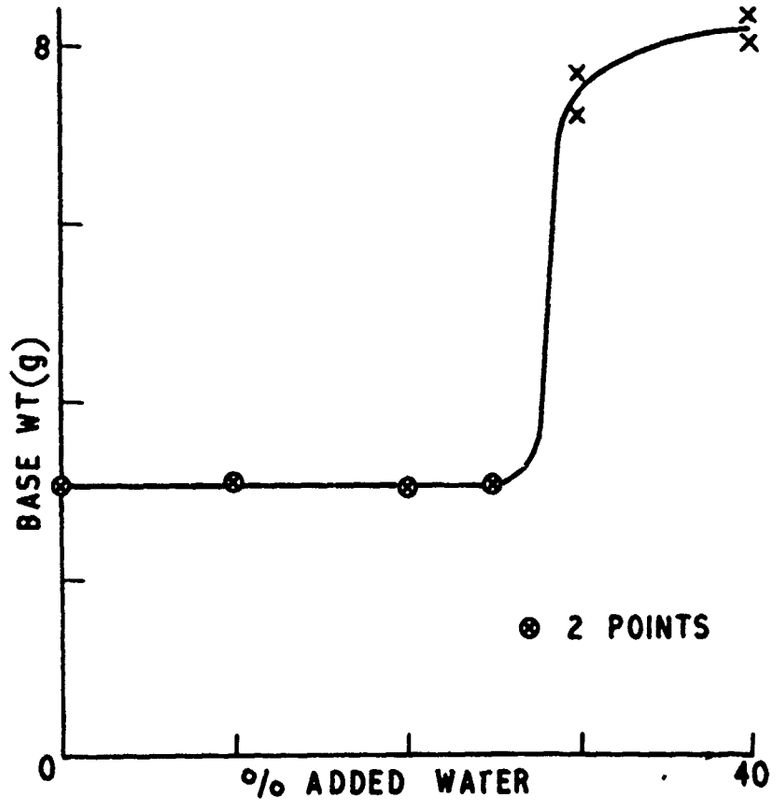


FIG. 11 C.C. TESTS OF STRONTIUM PICRATE / WATER

FIGS. 12 & 13

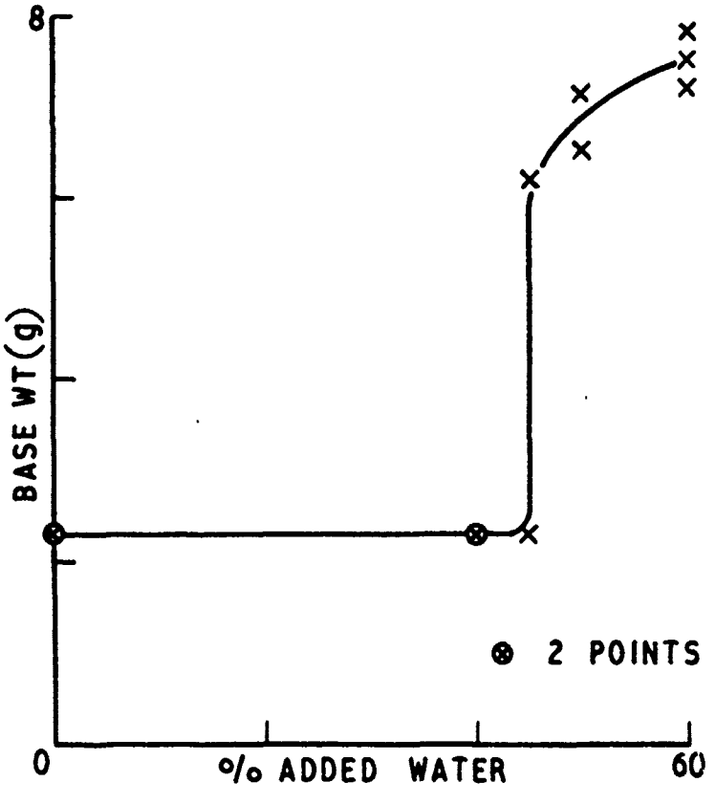


FIG. 12 C.C. TESTS OF TETRYL / WATER

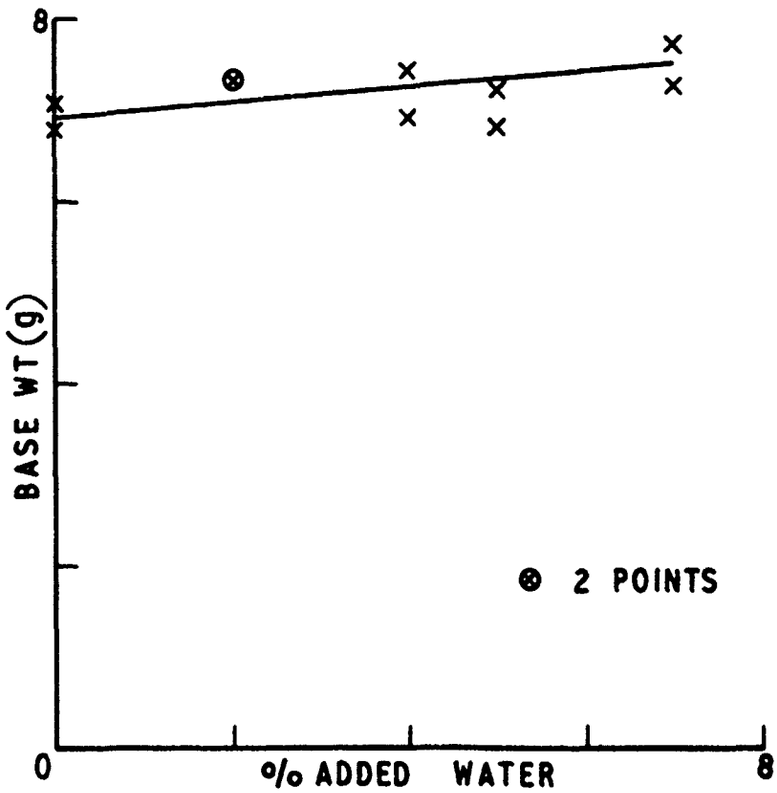


FIG. 13 C.C. TESTS OF GUNPOWDER / WATER

FIGS. 14 & 15

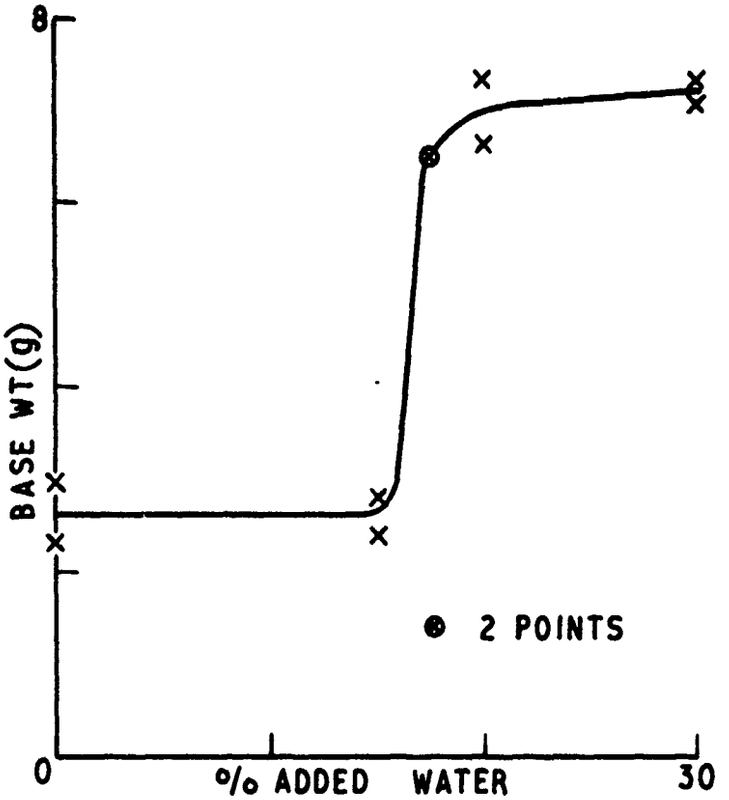


FIG. 14 C.C. TESTS OF STYPHNIC ACID (30 - 100 BSS) / WATER

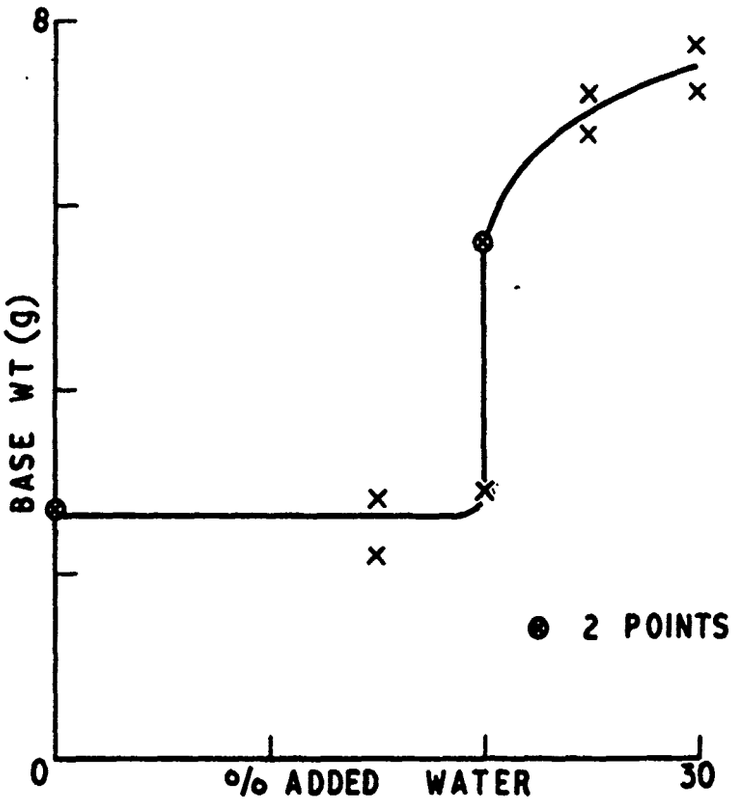


FIG. 15 C.C. TESTS OF STYPHNIC ACID (PASS 100 BSS) / WATER

FIGS.16 & 17

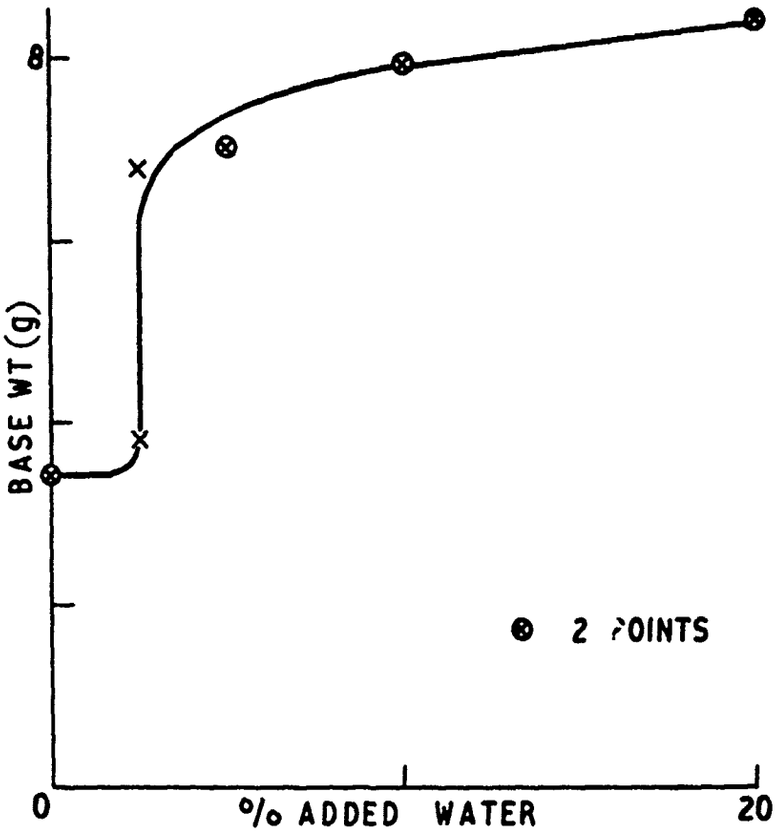


FIG.16 C.C. TESTS OF NITROGUANIDINE (40 - 80 BSS)/WATER

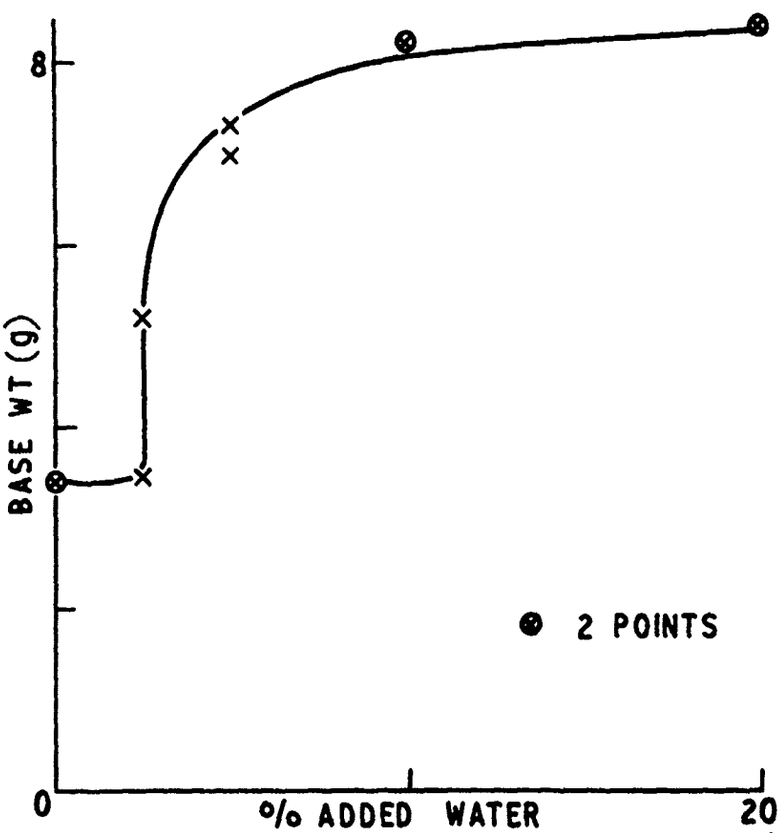


FIG.17 C.C. TESTS OF NITROGUANIDINE (PASS 80 BSS)/ WATER

FIGS. 18 & 19

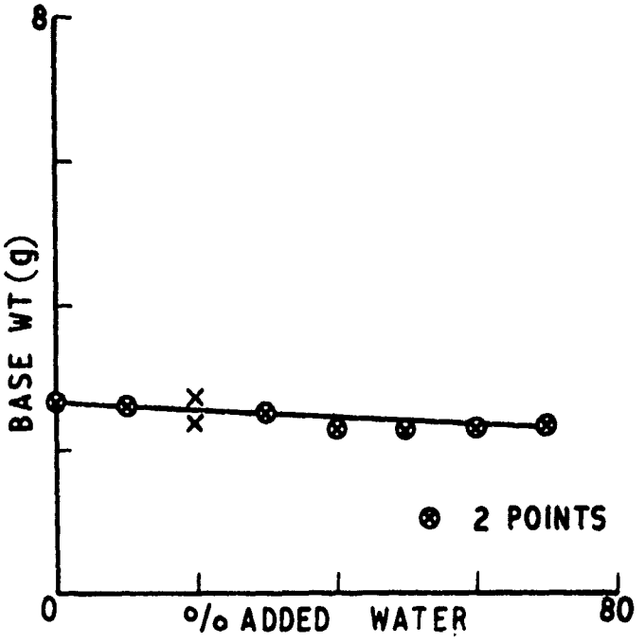


FIG. 18 C.C. TESTS OF PETN/WATER

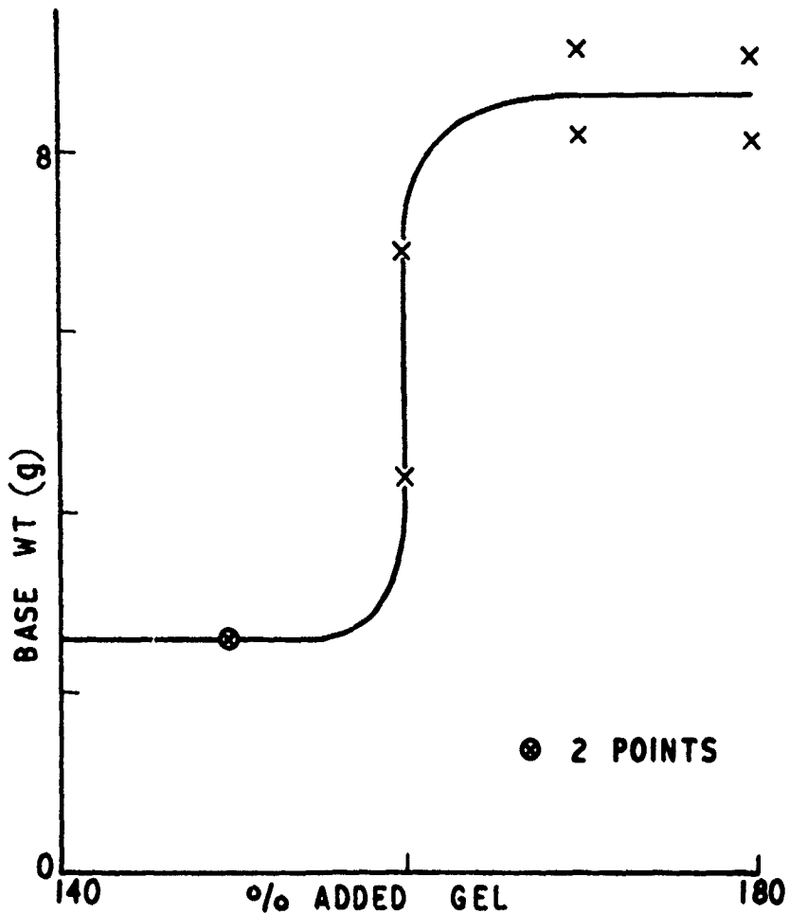


FIG. 19 C.C. TESTS OF PETN / GELLED WATER

FIGS. 20 & 21

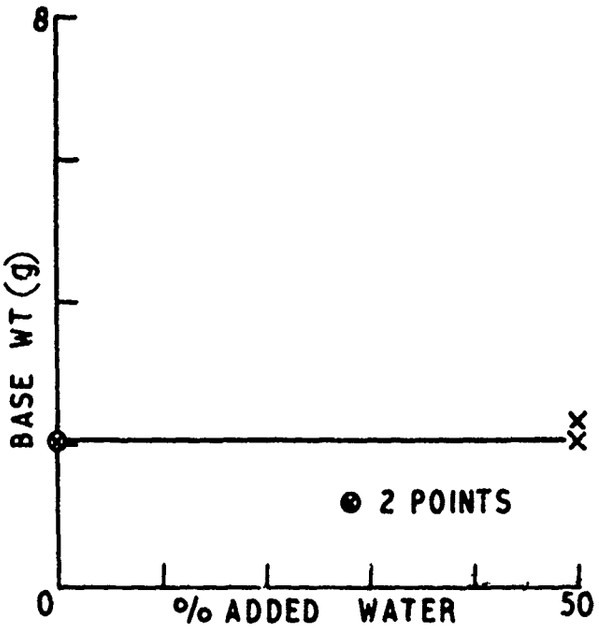


FIG. 20 C.C. TESTS OF RDX / WATER

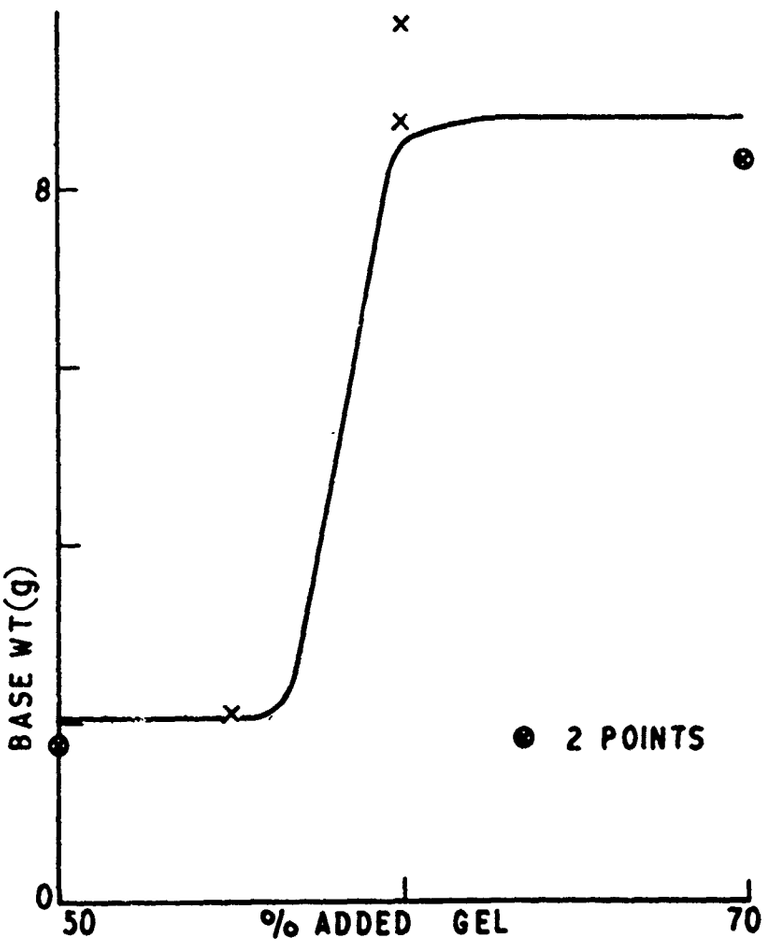


FIG. 21 C.C. TESTS OF RDX / GELLED WATER

FIGS. 22 & 23

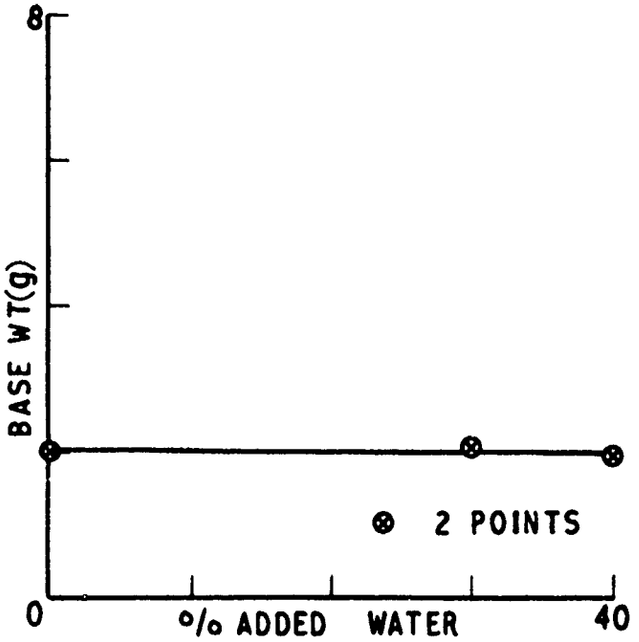


FIG. 22 C.C. TESTS OF RDX-TNT 80-20/WATER

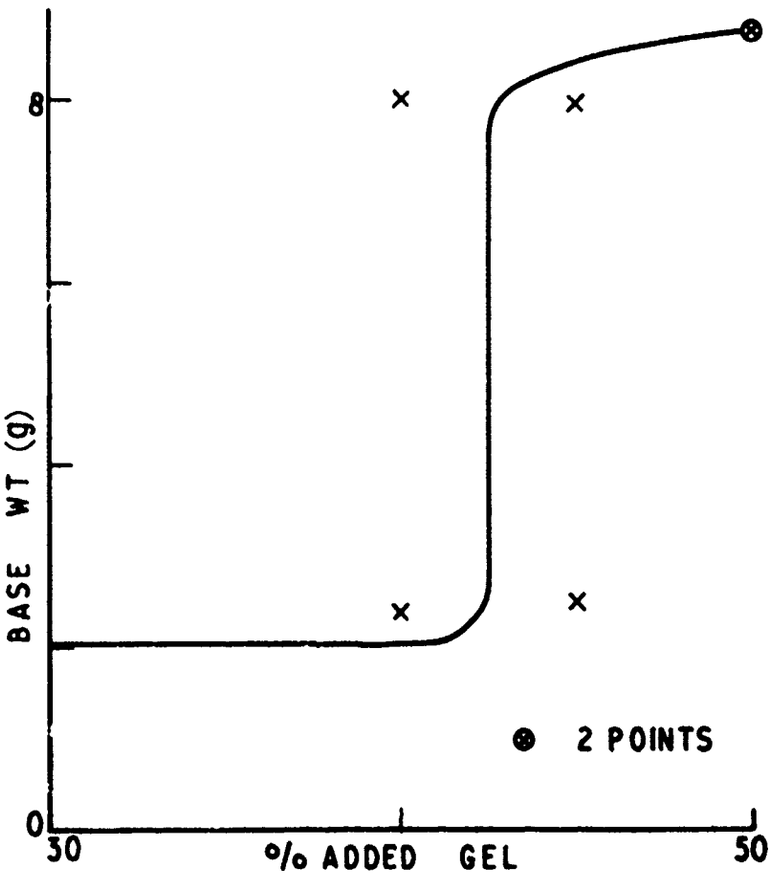
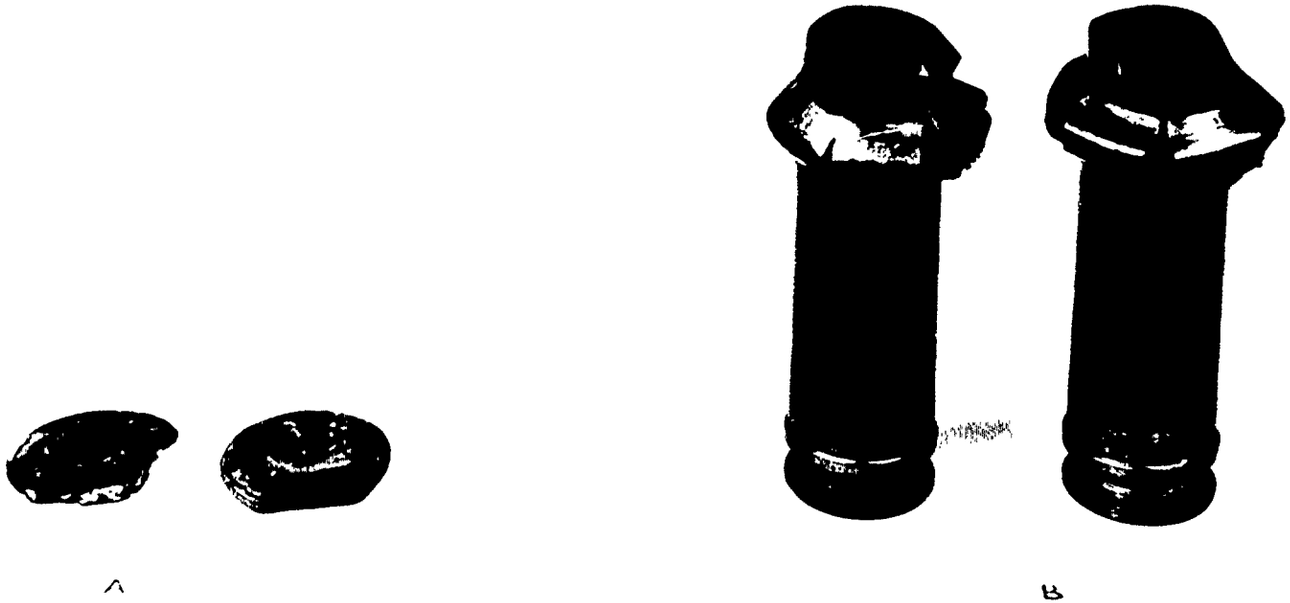


FIG. 23 C.C. TESTS OF RDX-TNT 80-20/GELLED WATER



A

B

FIG.24 DEFORMED CASES FROM LARGER SCALE FIRINGS OF TNT

A. WHEN DRY, GIVING DETONATION

B. WHEN WETTED WITH 20% WATER ADDITION, GIVING NON-EXPLOSIVE PERFORMANCE

FIG.24

FIG.25

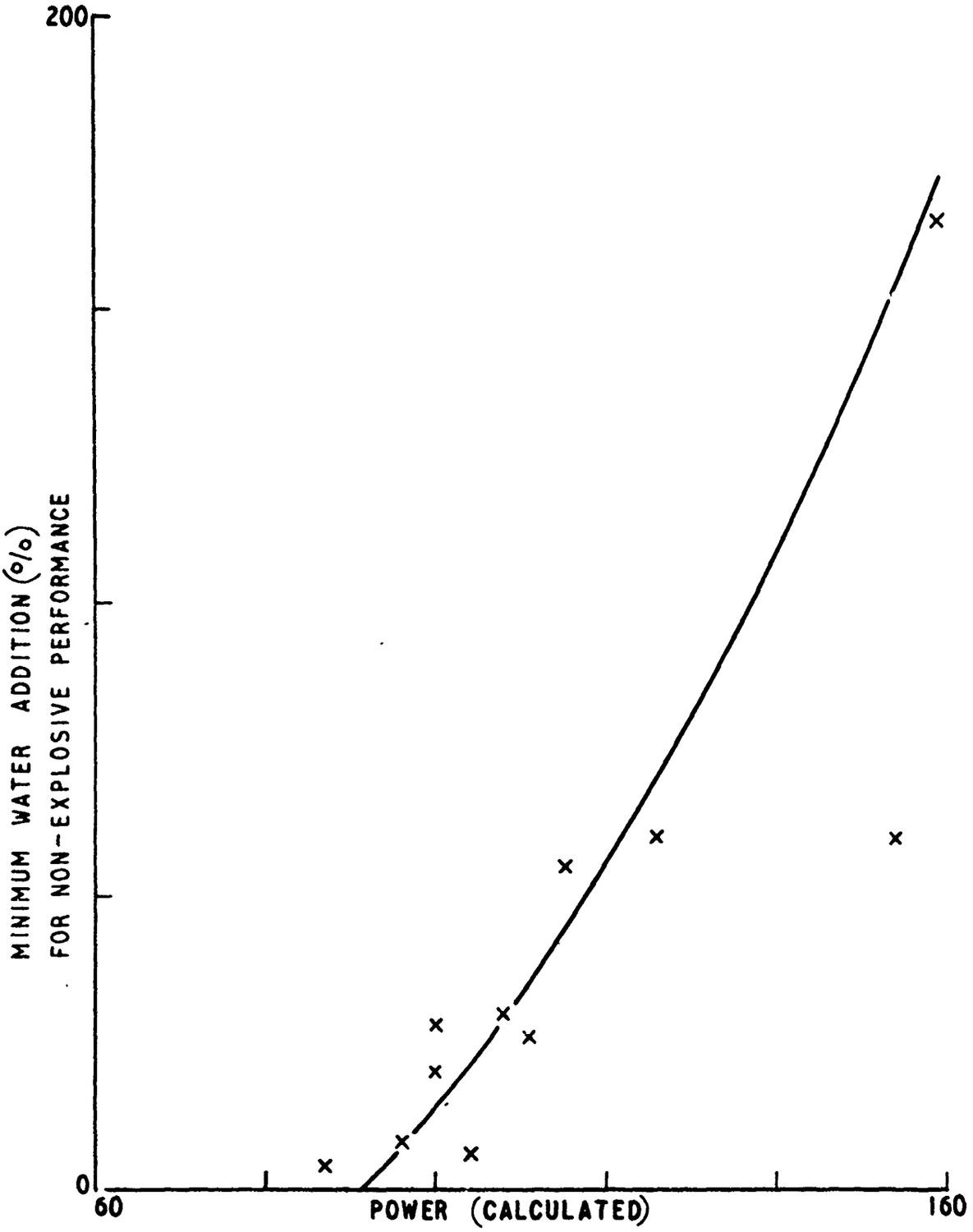


FIG. 25 RELATIONSHIP BETWEEN SAFE WETTING LEVEL AND EXPLOSIVE POWER

Ministry of Defence
Royal Armament Research and Development Establishment
RARDE Memorandum 38/72

662.215.2
623.452.5

The effect of added water on explosive performance as measured by the Lidstone Cartridge Case Test.

H C Sayce

December 1972

The desensitising effect of water on the explosive performance of 15 substances has been assessed by cartridge case deformation tests. The results appear to be valid for explosive in quantities appreciably larger than the test samples. Variations in particle size of an explosive are not likely to be significant.

19 pp 25 figs 4 tabs 5 refs

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19 pp 25 figs 4 tabs 5 refs

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